Nitrogen transfer in crustal rocks

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Nitrogen (N) is the sixth most abundant element in the solar system, the main component of the Earth's atmosphere and a key nutrient for life on Earth. The majority of the Earth's N is stored in the solid Earth [1], and N serves as a geochemical tracer for the exchange between atmosphere, oceans, crust and mantle over time. Knowledge of the distribution of N in the major crust and mantle reservoirs, and of the N isotopic compositions of these reservoirs, is necessary to fully understand modern and long-term N cycling on Earth and to track any interaction between these reservoirs. In this contribution, we address how subduction of N in oceanic crust and long-term storage of N in continental crust are relevant for contemporary N cycling.

The N subduction flux in deeply (50-90 km depth) subudcted oceanic crust is constrained by N contents of 2-20 ppm with mostly positive $\delta^{15}N_{air}$ values (-1 to +8 ‰; [2]) in eclogites. These values overlap those of altered oceanic crust and suggest deep retention of N in subducting oceanic crust, which could potentially deliver isotopically heavy N into the mantle. The major host mineral of N in metamorphosed oceanic crust is white mica, where N occurs as NH_4^+ and replaces K^+. Breakdown of white mica during high-pressure fluid-rock interaction can liberate N into fluids [3].

To constrain the N inventory of the deep continental crust and to understand how high-grade metamorphism and partial melting affects the N budget and N isotopes, we have analyzed metamorphosed mudstones from the Ivrea Zone [4]. The positive $\delta^{15}N_{air}$ values of these rocks agree well with values observed in modern sedimentary organic matter. Nitrogen concentrations decrease from up to 200 ppm at medium grades to ~10 ppm at high grades, consistent with decreasing modal amounts of biotite and loss of N in restites via biotite dehydration melting.

[1] Bebout et al., 2016, Amer. Mineral. 101:7-24.
[2] Halama et al., 2010, GCA 74:1636-1652.
[3] Halama et al., 2017, Int. Geol. Rev. *in press.*
[4] Bea & Montero, 1999, GCA 63:1133-1153.